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⑥ **Comparisons of performance effectiveness among divers,**

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Using a criterion of performance effectiveness derived from actual dives made under operational conditions, comparisons were made between U. S. Navy divers identified as high and low in performance effectiveness. Comparison measures included intelligence, anxiety, disciplinary problems, professional diving recognition, sick call visits, diving accidents, and incidence of decompression sickness (DCS). As expected, the most effective divers made more frequent and more hazardous dives than the least effective divers. In addition they had fewer diving accidents and a lower incidence of DCS. While the most effective divers had lower intelligence scores than the least effective group, both groups were substantially above the Navy average. These findings indicate that intelligence appears to be a critical variable in the career retention of divers, as well as the frequency and types of dives to which divers are exposed. The higher incidence of diving accidents and complications, especially DCS, found among the least effective divers may also have been involved in the lower frequency of diving observed among the members of this group.

THE DIVING PSYCHOLOGY research literature is rich in information about the aptitudes, behavior, and personalities of U. S. Navy divers. Aptitude test scores, especially verbal intelligence and mechanical and mathematical aptitudes, have been found to be related to performance in Diver First Class training (10). During SEALAB II, Radloff and Helmreich (9) showed that several personality, mood, and biographical factors were related to a composite performance score for saturation divers. This composite performance score consisted of

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ratings by diving supervisors, total hours in the water, number of telephone calls to the surface, as well as several other events important to saturation diving effectiveness. Biernser, Hall, and Linaweaer (6) also found that conventional and saturation divers could be differentiated using demographic and diving history information. Differentiating performance effectiveness among conventional divers engaged in routine diving operations is now also possible with the implementation of the Diving Log-Accident/Injury Report (OPNAV 9940/1).

Using information from OPNAV 9940/1, knowledge has been gained not only about the types of dives that are being made, but also about who is doing the diving. This research has shown, for example, that prior deep air diving experience does not reduce the performance effects of nitrogen narcosis (7). Age has also been shown to be an important factor in operational diving performance, with older divers making fewer dives and less hazardous dives than younger divers (4). Having demonstrated earlier that divers admitted to more pre-Navy antisocial behavior than other sailors matched for age, rate and pay grade (2), subsequent research showed that those divers high in antisocial behavior made fewer dives at cold temperatures but more night dives than those divers low in antisocial behavior (5). The anti-social divers were also more anxious and made more dispensary visits than the normal group. While these differences are not readily explained, a possible interpretation is that antisocial divers are worried or anxious about immediate physical comfort and well-being, thereby avoiding cold exposure and seeking medical attention more readily for minor ailments than normal divers. They are, however, apparently less apprehensive about more subtle dangers, as shown by the willingness of the antisocial group to make more night dives than the normal group.

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Having accumulated this body of knowledge about diver personality and behavior, can psychological research now identify those who are, or will be, the best divers under normal or routine operational diving conditions—those divers who make the most dives, the deepest dives, who dive in the coldest water, and who make the most night dives? In order to apply these findings to as broad a group as possible, the following research was limited to U. S. Navy Divers First and Second Class—the mainstay of U. S. Navy diving. This research compares a variety of characteristics between those divers who excel in these diving activities and those who do not.

MATERIALS AND METHODS

Diving and biographical information was obtained from 52 enlisted divers stationed at various diving units in the New London, CT, area during February, 1978. Information was collected on age, General Classification Test scores (GCT, a measure of verbal intelligence), years of diving experience, pre-Navy and in-Service disciplinary actions, diving accidents, and special recognition for diving performance (awards, commendations, etc). They were also asked to complete the Cornell Medical Index (CMI), which consists of a list of 200 possible physical and psychological symptoms. The CMI has been shown to be associated with anxieties about health and injury (1), and is also predictive of failure during diver training (8). The divers were asked to indicate which of these 200 symptoms are or have been problems. In addition, dispensary visits made by the divers at current duty stations were tabulated. Diving activity records for the period 1972-76 were obtained from the Naval Safety Center. These records included the total number of dives made over this period, the number of dives at depths deeper than 100 feet of sea water (31 m), the number of dives at surface air temperatures less than 50°F (10°C), and the number of dives made at night. Also obtained was the number of diving accidents, including decompression sickness (DCS) episodes, that occurred during this period.

In order to identify the most effective and least effective diver groups, the divers were rank-ordered in each of the four diving categories. By rank-ordering, the most effective diver was assigned a score of "1" and the least effective diver was assigned a "52". After the divers were rank-ordered, the average rank across the four categories was then determined for each diver. The diver with the lowest average score would therefore be the best overall diver across these four diving categories combined, while the diver with the highest average score would be the worst overall. In order to differentiate as much as possible between the most effective and the least effective divers, the 16 highest-ranked divers were compared to the 16 lowest-ranked divers for age, GCT scores, disciplinary action, CMI scores, etc. From previous research, the most effective divers were expected to be younger, score higher on the GCT and lower on the CMI, make fewer dispensary visits, have fewer diving accidents (including DCS), be recognized more often for diving excellence, and be involved in fewer disciplinary actions than the least effective divers. These comparisons were made using *t*-tests for indepen-

dent samples. Levels of significance were $p \leq 0.05$ (one-tailed).

RESULTS

Table I presents a summary of the findings. As expected, the most effective divers made substantially more dives per year on the average than the least effective divers (an average of one dive every 3.5 working days vs. one dive every 11 working days—assuming a 5-d work week and 30 d of leave/year).

The most effective divers also made nearly five times as many deep dives, 11 times the cold weather dives, and about 10 times the number of night dives as the least effective diver group. None of the other measures, except for GCT scores, differed significantly between the two groups. The most effective divers did not differ from the least effective divers in age, social adjustment as indicated by pre-Navy and in-Service disciplinary problems, self-reported health as assessed by the CMI, recognition for outstanding diving performance, or involvement in diving accidents. This last figure, however, is deceptive. The most effective divers reported that they had a similar accident rate to the least effective divers, even though they made more than three times the dives of the least effective diver group. This discrepancy is even more apparent with DCS episodes (obtained from Naval Safety Center records). The most effective diver group had only a single DCS episode in 4683 dives for the 5-year period, while the least effective group had four instances of DCS in 1510 dives. This discrepancy would be even larger if dives over 100 FSW, which are known to have a higher rate of DCS than shallow dives (3), were used for comparison. With an overall incidence for both groups combined of five DCS episodes in 6193 dives, the most effective divers would be expected to have had about four DCS episodes (3.78) and the least effective group about one DCS episode (1.22). The difference between actual and expected DCS episodes for the two groups was highly significant ($X^2 = 5.64$; $p < 0.02$), with the least effective divers having substantially more DCS episodes than expected, even though they made fewer total dives and fewer dives to depths over 100 FSW.

The other significant difference between the two groups involved GCT scores, with the most effective divers having significantly lower GCT scores than the least effective divers—a totally unexpected finding. This difference should be interpreted with caution, however, because the average GCT score of the effective group (56.94) is considerably higher than the overall Navy average of 50. The mean score of the least effective group (62.07) indicates that they are a superior intelligence group that is capable of succeeding academically in any training program the Navy offers.

DISCUSSION

These results substantiate an adage among psychologists that "The best predictor of future behavior is past behavior." Despite more than 15 years of research on the psychology of Navy divers using a variety of sophisticated tests and measures, the best predictors of overall diving performance are the separate components of that performance. Psychological characteristics in-

TABLE I. DIFFERENCES BETWEEN THE TWO DIVER GROUPS ON PRE-SERVICE, SERVICE, DIVING AND MEDICAL VARIABLES.

Variable	Most Effective Divers	Least Effective Divers	t	p
Pre-Service and Service History				
GCT Scores	56.53	62.23	2.12	<0.025
Years of Service	8.56	10.88	1.15	NS
Pre-Service Delinquency Problems	2.19	2.19	0.00	NS
In-Service Disciplinary Actions	1.69	1.75	0.06	NS
Diving Experience				
Years of Diving Experience	6.06	4.13	1.36	NS
Years of Naval Service Before Qualifying as a Diver	4.63	4.44	0.16	NS
Total No. of Dives/Yr.	60.96	19.17	5.71	<0.0005
Dives/Yr. at 50°F (10°C) or less	10.44	1.18	3.70	<0.0005
Night Dives/Yr.	2.67	0.27	2.86	<0.005
Dives/Yr. Below 100 FSW (31 m)	13.62	2.85	3.58	<0.005
Total Diving Accidents (self-report)	0.88	1.13	0.74	NS
Special Diving Recognitions/per diver	0.93	1.27	0.76	NS
Medical Information				
Age (years)	28.27	29.93	0.92	NS
CMI Score	13.93	16.93	0.43	NS
Sick Calls	3.61	3.57	0.46	NS

volving social adjustment, biomedical factors such as age and sick calls, and occupational data including years of diving and special diving recognition, were not especially useful in differentiating between those divers who made frequent and hazardous dives and those who made fewer dives. Before being too harsh on psychologists, however, these findings also indicate that Navy diving managers and supervisors also failed to differentiate between the two groups, as demonstrated by the results for special diving recognition. This category included not only awards and commendations for diving, but selection for special programs to test equipment or to serve as experimental volunteers. Apparently, selection for these programs involves factors other than previous diving experience. Inasmuch as such programs rely to some extent on volunteers, these findings indicate that the most effective divers do not volunteer more often than the least effective divers for such programs.

The findings for GCT scores and DCS incidence are difficult to interpret. The GCT differences are not sufficiently large to be of any practical significance, particularly in that both groups have mean GCT scores that are substantially above the overall Navy average. Perhaps the most likely explanation for these differences involves some type of assignment bias in which higher GCT personnel are placed more often in classroom and administrative positions that restrict the number and variety of diving experiences to which they are exposed. Another possibility, which may be involved in assuming administrative-classroom assignments, is that the high GCT divers are more verbally skilled and therefore better able to justify being assigned to less hazardous duties than lower GCT divers. These GCT results demonstrate, moreover, a possible fallacy in current aptitude standards for admission to diving training. While current standards would allow personnel with GCT scores in the 40s to attend diving school, these findings indicate that most of those who remain in the fleet have GCT scores at or above the mid-50s. Perhaps more research should be

done to determine the GCT levels for effective fleet performance, including retention beyond initial schooling.

The DCS incidence for these two groups of divers (five episodes in over 6000 dives) corresponds fairly well to the overall U. S. Navy incidence rate (5/10,000 dives) found earlier by Biersner (3). A review of the narrative summaries for these DCS episodes showed that the single episode for the most effective diver group was probably not DCS, having been attributed to a pulled muscle by the attending medical officer. (This diver did not get relief of pain on recompression to 60 FSW after two 20-min periods on oxygen.) The four DCS episodes for the least effective diver group were pain-only bends following deep air dives, with immediate relief of symptoms on recompression. These results demonstrate that the DCS episodes for the least effective diver group were legitimate cases and not mediated by fear or anxiety. This interpretation is supported further by comparing the CMI scores for both groups. Had the elevated DCS incidence rate for the least effective group been associated with anxiety about health and injury, then elevated CMI scores should have been found among this group. The possibility that this incidence rate involves non-compliance with standard decompression procedures is unlikely because these dives were made under strict U. S. Navy supervision. A more probable explanation is that some physical factor, perhaps a genetic/metabolic characteristic or perhaps a physical conditioning/adaptation effect, may be related to the occurrence of DCS. The higher incidence of DCS among the least effective group, as well as the higher incidence of general diving accidents, may have made some divers in the least effective group overly cautious about diving, accounting at least partly for the observed reduction in overall diving frequency among the least effective group. These results also demonstrate the importance of controlling for exposure or risk (frequency of diving, especially frequency of deep diving) before

DIVING EFFECTIVENESS—BIERSNER ET AL.

drawing conclusions about possible factors related to DCS.

These findings should not discourage psychological research on divers. The contributions of psychological research to date have done much to improve understanding of diver behavior. Much remains to be done, however, before effective operational diving performance can be identified with any accuracy. Until then the present results indicate that the best means of selecting divers for hazardous duty, especially if the risk of DCS is high, is to do so from available diving records.

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